

NAG Library Function Document

nag_rand_dirichlet (g05sec)

1 Purpose

nag_rand_dirichlet (g05sec) generates a vector of pseudorandom numbers taken from a Dirichlet distribution.

2 Specification

```
#include <nag.h>
#include <nagg05.h>

void nag_rand_dirichlet (Nag_OrderType order, Integer n, Integer m,
    const double a[], Integer state[], double x[], Integer pdx,
    NagError *fail)
```

3 Description

The distribution has PDF (probability density function)

$$f(x) = \frac{1}{B(\alpha)} \prod_{i=1}^m x_i^{\alpha_i-1} \quad \text{and}$$

$$B(\alpha) = \frac{\prod_{i=1}^m \Gamma(\alpha_i)}{\Gamma\left(\sum_{i=1}^m \alpha_i\right)}$$

where $x = \{x_1, x_2, \dots, x_m\}$ is a vector of dimension m , such that $x_i > 0$ for all i and $\sum_{i=1}^m x_i = 1$.

nag_rand_dirichlet (g05sec) generates a draw from a Dirichlet distribution by first drawing m independent samples, $y_i \sim \text{gamma}(\alpha_i, 1)$, i.e., independent draws from a gamma distribution with parameters $\alpha_i > 0$ and one, and then setting $x_i = y_i / \sum_{j=1}^m y_j$.

One of the initialization functions nag_rand_init_repeatable (g05kfc) (for a repeatable sequence if computed sequentially) or nag_rand_init_nonrepeatable (g05kgc) (for a non-repeatable sequence) must be called prior to the first call to nag_rand_dirichlet (g05sec).

4 References

Dagpunar J (1988) *Principles of Random Variate Generation* Oxford University Press

Hastings N A J and Peacock J B (1975) *Statistical Distributions* Butterworth

5 Arguments

1: **order** – Nag_OrderType

Input

On entry: the **order** argument specifies the two-dimensional storage scheme being used, i.e., row-major ordering or column-major ordering. C language defined storage is specified by **order** = Nag_RowMajor. See Section 2.3.1.3 in How to Use the NAG Library and its Documentation for a more detailed explanation of the use of this argument.

Constraint: **order** = Nag_RowMajor or Nag_ColMajor.

- 2: **n** – Integer *Input*
On entry: n , the number of pseudorandom numbers to be generated.
Constraint: $n \geq 0$.
- 3: **m** – Integer *Input*
On entry: m , the number of dimensions of the distribution.
Constraint: $m > 0$.
- 4: **a[m]** – const double *Input*
On entry: the parameter vector for the distribution.
Constraint: $a[i - 1] > 0.0$, for $i = 1, 2, \dots, m$.
- 5: **state[dim]** – Integer *Communication Array*
Note: the dimension, dim , of this array is dictated by the requirements of associated functions that must have been previously called. This array **MUST** be the same array passed as argument **state** in the previous call to nag_rand_init_repeatable (g05kfc) or nag_rand_init_nonrepeatable (g05kge).
On entry: contains information on the selected base generator and its current state.
On exit: contains updated information on the state of the generator.
- 6: **x[dim]** – double *Output*
Note: the dimension, dim , of the array **x** must be at least
 $\max(1, \mathbf{pdx} \times \mathbf{m})$ when **order** = Nag_ColMajor;
 $\max(1, \mathbf{n} \times \mathbf{pdx})$ when **order** = Nag_RowMajor.
Where $\mathbf{X}(i, j)$ appears in this document, it refers to the array element
 $x[(j - 1) \times \mathbf{pdx} + i - 1]$ when **order** = Nag_ColMajor;
 $x[(i - 1) \times \mathbf{pdx} + j - 1]$ when **order** = Nag_RowMajor.
On exit: the n pseudorandom numbers from the specified Dirichlet distribution, with $\mathbf{X}(i, j)$ holding the j th dimension for the i th variate.
- 7: **pdx** – Integer *Input*
On entry: the stride separating row or column elements (depending on the value of **order**) in the array **x**.
Constraints:
if **order** = Nag_ColMajor, $\mathbf{pdx} \geq \mathbf{n}$;
if **order** = Nag_RowMajor, $\mathbf{pdx} \geq \mathbf{m}$.
- 8: **fail** – NagError * *Input/Output*
The NAG error argument (see Section 2.7 in How to Use the NAG Library and its Documentation).

6 Error Indicators and Warnings

NE_ALLOC_FAIL

Dynamic memory allocation failed.

See Section 3.2.1.2 in How to Use the NAG Library and its Documentation for further information.

NE_BAD_PARAM

On entry, argument $\langle value \rangle$ had an illegal value.

NE_INT

On entry, $m = \langle value \rangle$.

Constraint: $m > 0$.

On entry, $n = \langle value \rangle$.

Constraint: $n \geq 0$.

NE_INT_2

On entry, $pdx = \langle value \rangle$ and $m = \langle value \rangle$.

Constraint: $pdx \geq m$.

On entry, $pdx = \langle value \rangle$ and $n = \langle value \rangle$.

Constraint: $order = \text{Nag_ColMajor}$ or $pdx \geq n$.

NE_INTERNAL_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please contact NAG for assistance.

An unexpected error has been triggered by this function. Please contact NAG.

See Section 3.6.6 in How to Use the NAG Library and its Documentation for further information.

NE_INVALID_STATE

On entry, **state** vector has been corrupted or not initialized.

NE_NO_LICENCE

Your licence key may have expired or may not have been installed correctly.

See Section 3.6.5 in How to Use the NAG Library and its Documentation for further information.

NE_REAL_ARRAY

On entry, at least one $a[i] \leq 0$.

7 Accuracy

Not applicable.

8 Parallelism and Performance

`nag_rand_dirichlet` (g05sec) is threaded by NAG for parallel execution in multithreaded implementations of the NAG Library.

Please consult the x06 Chapter Introduction for information on how to control and interrogate the OpenMP environment used within this function. Please also consult the Users' Note for your implementation for any additional implementation-specific information.

9 Further Comments

None.

10 Example

This example prints a set of five pseudorandom numbers from a Dirichlet distribution with parameters $m = 4$ and $\alpha = \{2.0, 2.0, 2.0, 2.0\}$, generated by a single call to `nag_rand_dirichlet` (g05sec), after initialization by `nag_rand_init_repeatable` (g05kfc).

10.1 Program Text

```

/* nag_rand_dirichlet (g05sec) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */
/* Pre-processor includes */
#include <stdio.h>
#include <math.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagg05.h>

#define X(I, J) x[(order == Nag_ColMajor)?(J*pdx + I):(I*pdx + J)]

int main(void)
{
    /* Integer scalar and array declarations */
    Integer exit_status = 0;
    Integer pdx, x_size, i, j, lstate;
    Integer *state = 0;

    /* NAG structures */
    NagError fail;

    /* Double scalar and array declarations */
    double *x = 0;

    /* Set the distribution parameters */
    double a[] = { 2.0e0, 2.0e0, 2.0e0, 2.0e0 };
    Integer m = 4;

    /* Set the sample size */
    Integer n = 5;

    /* Return the results in column major order */
    Nag_OrderType order = Nag_ColMajor;

    /* Choose the base generator */
    Nag_BaseRNG genid = Nag_Basic;
    Integer subid = 0;

    /* Set the seed */
    Integer seed[] = { 1762543 };
    Integer lseed = 1;

    /* Initialize the error structure */
    INIT_FAIL(fail);

    printf("nag_rand_dirichlet (g05sec) Example Program Results\n\n");

    /* Get the length of the state array */
    lstate = -1;
    nag_rand_init_repeatabl(genid, subid, seed, lseed, state, &lstate, &fail);
    if (fail.code != NE_NOERROR) {
        printf("Error from nag_rand_init_repeatabl (g05kfc).\n%s\n",
            fail.message);
        exit_status = 1;
        goto END;
    }

    pdx = (order == Nag_ColMajor) ? n : m;
    x_size = (order == Nag_ColMajor) ? pdx * m : pdx * n;

    /* Allocate arrays */
    if (!(x = NAG_ALLOC(x_size, double)) ||
        !(state = NAG_ALLOC(lstate, Integer)))

```

```

{
  printf("Allocation failure\n");
  exit_status = -1;
  goto END;
}

/* Initialize the generator to a repeatable sequence */
nag_rand_init_repeatable(genid, subid, seed, lseed, state, &lstate, &fail);
if (fail.code != NE_NOERROR) {
  printf("Error from nag_rand_init_repeatable (g05kfc).\n%s\n",
        fail.message);
  exit_status = 1;
  goto END;
}

/* Generate the variates */
nag_rand_dirichlet(order, n, m, a, state, x, pdx, &fail);
if (fail.code != NE_NOERROR) {
  printf("Error from nag_rand_dirichlet (g05sec).\n%s\n", fail.message);
  exit_status = 1;
  goto END;
}

/* Display the variates */
for (i = 0; i < n; i++) {
  for (j = 0; j < m; j++)
    printf("%10.4f", X(i, j));
  printf("\n");
}

END:
  NAG_FREE(x);
  NAG_FREE(state);

  return exit_status;
}

```

10.2 Program Data

None.

10.3 Program Results

nag_rand_dirichlet (g05sec) Example Program Results

0.3600	0.3138	0.0837	0.2426
0.2874	0.5121	0.1497	0.0509
0.2286	0.2190	0.3959	0.1566
0.1744	0.3961	0.2764	0.1530
0.1522	0.2845	0.2074	0.3559
